GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

4428

Date: 12/11/78

Project Title: 95 GHz Radar Measurement Program

Project No: A-2241

Project Director: Mr. J. A. Scheer

Sponsor: Standard Elektrik Lorenz AG; Stuttgart, W. GERMANY

Agreement Period: From 10/1/78 Until 9/30/79

Type Agreement: Standard Industrial dated 11/14/78 (SEL Purch. Ord. No. 403450-93-522791-788922930)

Amount: $136,144.00(Partially funded @ $84,545 for Phases 1&2).

Reports Required: Monthly Progress Letters; Final Technical Report.

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

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Standard Elektrik Lorenz AG
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Phone: (0711)821-3260
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Defense Priority Rating: None

Assigned to: Radar Instrumentation Laboratory (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
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Project Code (GTRI)
Other_____

OA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: June 30, 1980

Project Title: 95 GHz Radar Measurement Program

Project No: A-2241

Project Director: Mr. J. A. Scheer

Sponsor: Standard Elektrik Lorenz AG; Stuttgart, W. GERMANY

Effective Termination Date: September 30, 1979

Clearance of Accounting Charges: --

Grant/Contract Closeout Actions Remaining:

None

_ Final Invoice and Closing Documents
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other _____

Assigned to: RAIL/RDD (School/Laboratory)

COPIES TO:

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Project Code (GTRI)
Other _____

CA–4 (1/79)

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

19 May 1980

Standard Elektric Lorenz AG
Product Division Navigation
Hellmuth-Hirth-Strasse 42
D-7000 Stuttgart 40 (Zuffenhausen)
West Germany

Attention: Mr. Volker Kloevekorn

Subject: Monthly Contract Technical Status Reports No. 1 Through 10
on P. O. No. 403450-93-522791-788922930 (A2241)
Covering the Period October 1978 Through July 1979
"95 GHz Radar Measurement Program"

Dear Sir:

This is a compilation of the progress of activities during the referenced period of time on the program entitled "95 GHz Radar Measurement Program."

The contract was received in October 1978 and work was immediately begun to plan the tests, prepare equipment for the program and prepare travel arrangements for the personnel. Engineering personnel assigned to the program were: Jim Scheer,Project Director; David Ladd, Lucien Bomar and Mel West.

During October, Volker Kloevekorn, the SEL Technical Monitor, visited Georgia Tech to help define the program goals and develop the test plan.

Also during October 1978, the 95 GHz radar system, tape recorder and various other test equipment items and tools were assembled and prepared for shipment. The equipment was packaged and delivered to a shipping agent for processing through customs. Jim Scheer departed for Stuttgart, Germany on 29 October 1978.

The first week of November was spent in Stuttgart awaiting arrival of the equipment and preparing sections of the SEL final report. The radar equipment was received and cleared through German customs on 6 November and loaded into the SEL van and driven to the Graffenwohr area on 7 November. David Ladd flew into Nurnberg on 7 November and joined the project personnel who included Jim Scheer, Volker Kloevekorn, and Conrad Weiss.

The period of 8 November through 13 November were spent setting up the equipment in the van.

The first set of clutter and target measurements was made from 14 November to 16 November. These included, in addition to corner reflector calibration, the following:

- o M113 APC at 0° to 315° aspect in 45° steps
- o M113 APC Rotating
- o M113 APC Closing
- o Doppler Simulator
- o Ground Clutter Map - 5 Azimuth Bins by 5 Range Bins
- o Tree Trunks and Tree Foliage
- o Walking Man

All of these measurements were made using linear and circular polarization.

Lucien Bomar arrived in Germany to replace Jim Scheer for the remainder of the measurements, to begin on 20 November. Actual data collection occured during the time between 28 November and 1 December 1978. Targets included:

- o Isolated Tree Trunk
- o APC
- o M109 Tank at 0°, 45°, 90°
- o M109 Tank Turning
- o Tree Trunk Clutter
- o Tree Line
- o 2.5 Ton Red Cross Truck @ 0°, 45°, 90°
- o 2.5 Ton Red Cross Truck Turning
- o 5 Ton Red Cross Truck @ 0°, 45°, 90°
- o 5 Ton Red Cross Truck Turning
- o Vehicles in Clutter Cells

These measurements were also made using both linear and circular polarizations.

The equipment was packed up and the project personnel returned to Atlanta during the first week of December 1978.

During the months of January, February and March of 1979 the data tapes were analyzed and the resulting plots were supplied to SEL.

On 4 May 1979 a set of moving target measurements was made on two Georgia Tech vehicles, the multifrequency van and the 70 GHz van, both reconfigured M109 vans. They were driven at 5, 10 and 15 miles per hour (8, 16, 24 km/m) speeds at two aspect angles, 0° and 45° (0° and 45°). These data were also supplied to SEL. This completed the effort on this project, with the exception of planning for the follow-on effort.

Respectfully submitted.

James A. Scheer
Chief, Development Division
RAIL

JAS/vcy

Approved:

J. L. Eaves
Associate Director
RAIL

Final Technical Report

95 GHz Radar Measurement Program
P. O. 508050-93-534351-788322938

by

L. C. Bomar
J. A. Scheer

Prepared for

Standard Elektrik Lorenz AG
Product Division Navigation
Hellmuth-Hirth-Strasse
D-7000 Stuttgart 40 (Zuffenhausen), Germany

May 1980

Georgia Institute of Technology
Engineering Experiment Station
Radar and Instrumentation Laboratory
Radar Experimental Divsion
Atlanta, Georgia USA 30332

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1.0 INTRODUCTION

This final technical report documents a 95 GHz radar measurements program conducted by the Engineering Experiment Station (EES) at the Georgia Institute of Technology, Atlanta, Georgia, USA, for Standard Elektrik Lorenz (SEL) AG, Stuttgart, Germany. These tests were conducted in two phases during the period 18 June 1979 through 13 July 1979, near Grafenwohr, FRG, and were designed to provide 95 GHz radar reflectivity data from dust and smoke and from selected targets of opportunity. The 95 GHz radar support equipment and personnel were supplied by the EES while on-site facilities, logistics and project supervision were supplied by SEL. The data collected is to be used by SEL in analysis and development of 95 GHz radar concepts.

1.1 Program Objectives

Two sets of measurements were performed during the measurement program and denoted as Phase I and Phase II. The Phase I measurements consisted of a set of attenuation and backscatter measurements due to smoke and dust created in a tactical battlefield environment. These measurements were made in conjunction with the NV&EOL Grafenwohr IIB realistic battlefield tests in the Grafenwohr area between 18 June 1979 and 29 June 1979. The objective of the program was to determine the attenuation backscatter and turbulence induced scintillation of artillery explosion within the radar field of view.

Phase II measurements consisted of a separated set of measurements involving the characterization of the backscatter from a specific class of clutter and selected tactical vehicles. The objective of this phase was to extend the current 95 GHz data base in these areas and supply SEL with data from which system design and performance could be extrapolated and from which various signal processing application might be developed.

1.2 Program Tasks

The specific tasks performed by the EES were as follows:

Phase I

(1) Prepare the Georgia Tech 95 GHz radar for field measurements at Grafenwohr.

(2) Provide all necessary on-site data collection and data analysis equipments.

(3) Provide calibrated retro-reflectors suitable for attenuation, backscatter calibrations.

(4) Conduct a series of measurements in conjunction with the NV&EOL Grafenwohr IIB realistic battlefield test between 18-30 June 1979.

(5) Supply data tapes, calibration and detailed data logs to SEL for subsequent analysis.

Phase II

(1) Prepare the Georgia Tech 95 GHz radar for special polarization related measurements.

(2) Provide data tape recorder and data acquisition and instrumentation equipment.

(3) Perform series of clutter and target-in-clutter measurements for data analysis. This task included recording of the data on FM tape.

(4) Supply data tapes to SEL for subsequent analysis.

2.0 RADAR EQUIPMENT

Phase I

The radar used in the Phase I measurements was a Georgia Tech 95 GHz radar. The radar was vertically polarized for transmit and contained a dual polarized receiver (horizontal and vertical). The radar used a 1 kW extended interaction oscillator with a 250 nanosecond pulsewidth as the transmitter. Figure 1 is a block diagram of the radar configuration and Table I is a listing of the pertinent characteristics of the radar.

In addition to the radar a set of 6 sample and hold circuits were interfaced with the radar video to create 6 independent range gates for sampling of the radar data. These samples produced a boxcar output at the radar prf which in turn was recorded on an fm magnetic tape recorder for subsequent analysis.

Phase II

The Georgia Tech 95 GHz magnetron radar used for the Phase II measurements was modified to provide a random switching of the polarization on a pulse-to-pulse basis. Both linear and circular polarizations were used but the emphasis was on switching between right and left circular polarization on a pulse-to-pulse basis. In some cases this switching was randomly excited using a 217 pulse sequence. A signal indicating the polarization state was also provided for recording. Figure 1 and Table I suffice to describe the radar used in Phase II tests.

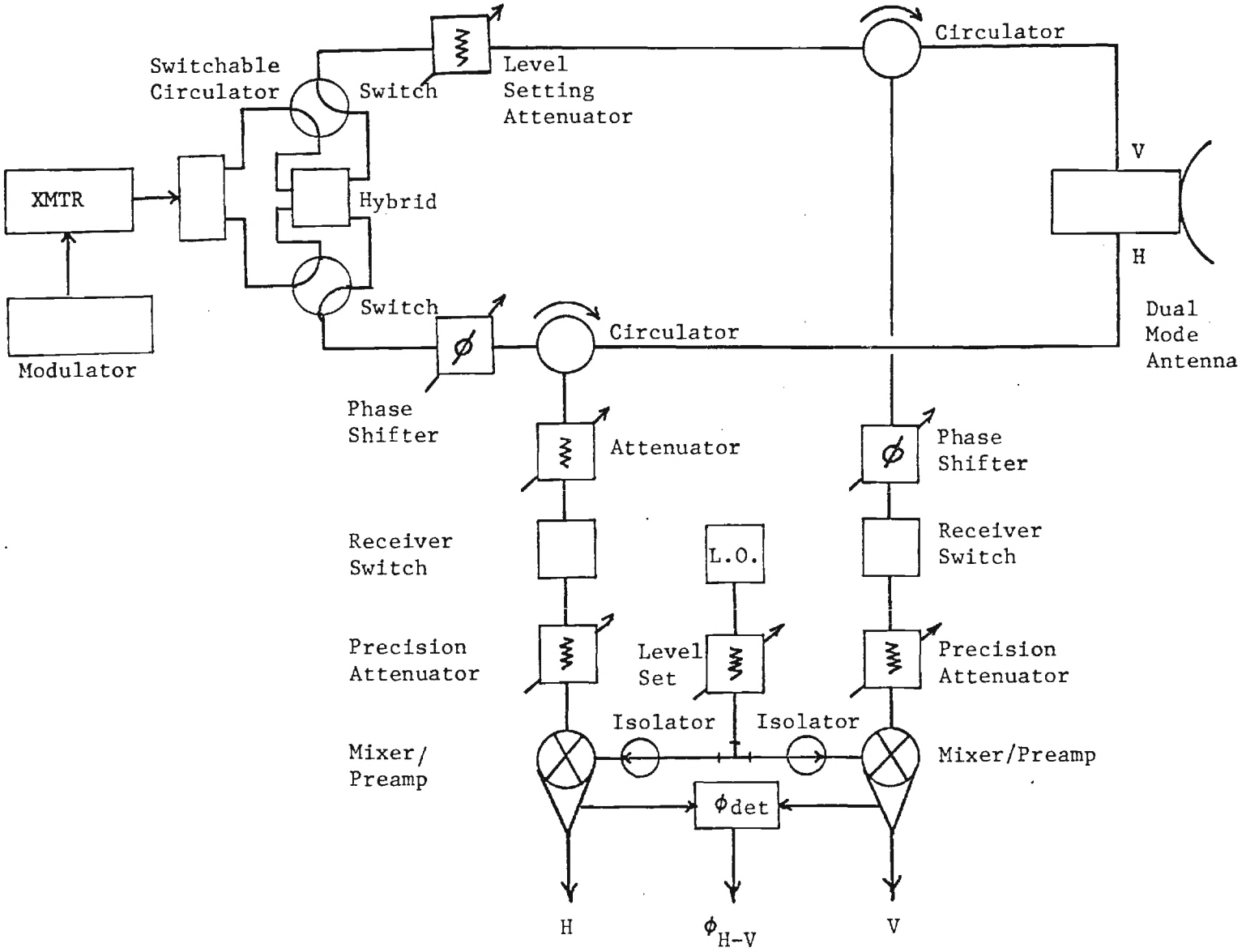

Figure 1. Radar Block Diagram

TABLE I. 95 GHz System Parameters

	Phase I	Phase II
Transmitter		
Type	EIO	Magnetron
Frequency	94.8 - 95.2 GHz	95.3 GHz
Peak Power	1 kW	1 kW
PRF	2 kHz	2.44 kHz
Pulse Width	250 ns	50 ns
Polarization	V	H, V, RC, LC
Receiver		
Type	Logrithmic	Logrithmic
Center Freq.	300 MHz	300 MHz
Bandwidth	200 MHz	200 MHz
Dynamic Range	70 dB	70 dB
Sensitivity	-80 dBm	-80 dBm
Polarization	V	H,V
Detection	V	V,H,ϕ_{H-V}
Antenna		
Type	12" Cassegrain	12" Cassegrain
Beamwidth	0.7^{o}	0.7^{o}
Gain	47 dB	47 dB
Sidelobes	-20 dB	-20 dB
Polarization:		
Receiver	V	H,V
Transmit	V	H,V,RC,LC

3.0 95 GHz FIELD MEASUREMENT DESCRIPTION

3.1 Phase Measurements

The 95 GHz radar system and associated support equipments were transported from Atlanta, Georgia to the SEL facilities in Stuttgart, FRG. The equipment was unpacked and carried to the NVL facilities in Grafenwohr designated as TAC-5. TAC-5 was used as a stagging area in which the Georgia Tech radar and equipment were installed in the SEL van. Equipment installation was carried out on June 18 and 19th with system check-out and calibration completed on June 20th.

The SEL van was moved from TAC-5 to the test site near the impact zone on June 21st. The radar system was powered and boresighted to a corner reflector located across the impact zone at RIM I.

Test measurements began on June 25 and continued through June 28th. The measurement consisted of the recording of backscatter and attenuation due to artillery rounds in single shot and barrage. The data were recorded on 7 channel fm tape and were compiled on 2 tapes. The equipment and SEL van were removed from the target area on the afternoon of June 28th.

3.2 Phase II Measurements

On July 2, the van with the 95 GHz magnetron radar was moved onto the test site for the target and clutter measurements. These measurements were taken during the periods from 3 July to 12 July. Target cells included several disabled, but representative tactical targets, placed in various locations in the field of view. Some were near clusters of trees, some near tree lines, one was in a depression and some were in relatively open areas.

Clutter cells included tree clusters, single trees, bushes and grassy areas.

Linear and circular polarizations were used, both in the fixed mode and in the pulse-to-pulse agile mode.

3.3 Other Tasks

At the conclusion of the Phase II measurements, the equipment was prepared for travel to SEL where it was to be packed for shipment back to Atlanta.

4.0 RESULTS AND RECOMMENDATIONS

Since SEL maintained the responsibility for analyzing the data, the results will not be reported here.

There is an additional question which needs to be answered in regard to reflectivity characterization of targets and clutter at 95 GHz in the European scenario. It involves higher depression angle measurements than those at which these tests were run. It is suggested that a follow-on program be planned, which will allow for high depression angle tests, such as can be performed from a tower or bridge.